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Khoulood Boukadi, Lucien Vincent, Chirine Ghedira. A Multi-layer Framework for Virtual Organizations Creation in Breeding Environment. Luis M. Camarinha-Matos; Xavier Boucher; Hamideh Afsarmanesh. Collaborative Networks for a Sustainable World, 336, Springer, pp.287-296, 2010, IFIP Advances in Information and Communication Technology, 978-3-642-15960-2. <10.1007/978-3-642-15961-9_34>. <hal-01055981>

HAL Id: hal-01055981

<https://hal.inria.fr/hal-01055981>

Submitted on 25 Aug 2014

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A Multi-layer Framework for Virtual Organizations Creation in Breeding Environment

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Abstract. Nowadays collaboration among organizations in the so called Virtual Organizations (VOs) is the most advanced form to make business. Their emergence and growing are closely related to integrated information and communication technology (ICT). One of the promising approaches to carry out the agility and flexibility in VO creation is defined under the assumption of a VO Breeding Environment (VBE). To support such agile organizations, an efficient IT system and methodologies should be set in order to facilitate their daily management activities. Service-oriented software technologies provide promising means to regulate and enforce coordination of cross-organisational business services interactions but lack organizational abstractions and methodology. This paper proposes a framework for collaborative network coordination in the VBEs's context. The proposed framework satisfies flexibility and agility requirements of virtual organization using a multi layer approach combining VBE management systems layer that assist flexible VO creation, a semantic interoperability layer essential for promoting integration on the basis of common language that describe VO concepts and inherent dependencies, and a service oriented layer that introduces the concept of service domain that encapsulates business processes fitting VO requirements.

Keywords: Virtual Organizations, VO Breeding Environment,

1. INTRODUCTION

In response to global competition, rapid changes in market conditions, increased customer selectivity on prices, many companies are restructuring their organizations to achieve more flexibility. Organizations migrate to inter-organizational relationships and especially to collaborative networks as a way to adapt to their new environment, to increase their efficiency, and to gain competitive advantages.

The concept of virtual organization (VO) represents one of the most discussed examples of collaborative networks [1], that is centered on the realization of specific product types and consisting of a possibly large number of autonomous organizations. The virtual organization form is nowadays receiving ample attention [2]. There are a number of different definitions and uses for the VO concept. Our definition follows the one proposed by [3]: “VO is an association of (legally) independent organizations (VO partners) that come together and share resources and skills to achieve common goals, such as acquiring and responding to a market/society opportunity”.

Both research and practice have shown that dynamic creation of VOs, driven by the emergence of new opportunities, faces a large number of challenges. For example, finding the right partners and establishing on demand collaborative business process have proved to be costly in terms of time and effort [2]. Other barriers include lack of information, lack of common collaboration infrastructure and heterogeneity of potential partners (e.g. in ICT infrastructures, culture and business practices)

The concept of Virtual Organizations Breeding Environment (VBE) is therefore introduced to address many challenges involved in the establishment and management of these VO. The VBE is not a new concept as a large number of related initiatives have emerged during the last decades, and a set of various case studies are presented (e.g. Virtuelle Fabrik, Switzerland; IECOS, Mexico; CeBeNetwork, Germany; etc.). However, these cases use little support from ICT tools and are governed by a limited conceptual framework. Consequently, a growing number of works has been published that present new models and conceptual frameworks for VBEs as well as for dynamic creation of VOs within the VBEs.

We consider that overcoming the VO obstacles within the VBE context forces organizations to abandon traditional modes to design business processes to embrace an entirely new paradigm based on service oriented vision. Service-oriented software technologies provide promising means to regulate and enforce coordination of cross-organisational business services interactions but lack organizational abstractions and methodology. Hence a comprehensive framework to guide and manage organizations within a VBE, considering business services as a first building block for collaborative business process, is still missing.

For this reason, we propose in this paper a framework that satisfies flexibility and agility requirements of VO using a multi layer approach combining VBE management systems layer that assist flexible VO creation, a semantic interoperability layer essential for promoting integration on the basis of common language that describe VO concepts and inherent dependencies, and a service oriented layer that introduces the concept of service domain that encapsulates business processes fitting VO requirements.

The remainder of this paper is organized as follows. In section 2, we describe briefly the VO breeding environment, the service oriented architecture and the semantic interoperability and ontology. Section 3 presents the proposed layered framework with more stress on layer's functionalities. Finally, some concluding remarks and future research directions are presented.

2. Background

2.1 Virtual organizations Breeding Environment

A Virtual organization Breeding Environment (VBE) is defined by [5], [6] as “an association of organizations and their related supporting institutions, adhering to a base long-term cooperation agreement, and adoption of common operating principles and infrastructures, with the main goal of increasing both their chances and their preparedness towards collaboration in potential Virtual Organizations”.

A diversity of roles can be achieved by actors in the VBE, where an actor represents either a VBE member organization or an individual representing a VBE member

organization [8],[9]. The same organization may undertake different roles, e.g. acting as a VO participant, a VO broker, etc. where each role requires assigning different rights/responsibilities within the VBE.

2.2 Service Oriented Architecture (SOA)

A Service-Oriented Architecture (SOA) is an architectural style that proposes a set of patterns and guidelines for creating loosely coupled, business-aligned services [10]. Service oriented architecture plays an ever more important role in modern networked economies. SOA can reinforce business aspects with a flexible infrastructure thanks to independent, reusable automated business process called services. This trend is leading paradigm shift in enterprise structure from the traditional single entity to a collaboration of services. So from this perspective, the goal of the SOA is to allow autonomous partners to advertise their terms and capabilities, to engage in peer-to-peer interactions with any other partners and to enable on demand computing through composition and outsourcing [12] [13]. SOA addresses the requirements of loosely coupled, standard-based, and protocol-independent distributed computing.

2.3 Semantic interoperability and Ontology

Semantic interoperability is a crucial issue for the successful development and further growth of VO paradigm. Within the VO, different and independent organizations need to cooperate and share heterogeneous information resources. Accessing heterogeneous and distributed informational resources requires appropriate semantic interoperability techniques [14]. These techniques target to enable a seamless access and retrieval of the right information resources. Semantic interoperability and its content description standards are based on ontologies and their inherent rules. There are several ontology definitions that have evolved in the last decades. However, there is a consensus among the ontology community of researchers about their role: they provide a common understanding regarding domain knowledge. In the context of VBE, we consider ontologies as an essential tool for allowing communication and knowledge sharing among distributed organizations, by providing a semantically rich description and a common understanding of a domain of interest [15].

3. Multi-Layer framework for Virtual Organizations creation

In this section, the multi-level framework that supports and facilitates the operation and management of a VBE is exposed. This framework is presented in terms of concepts, duties per layer, and components specifications (Figure 1).

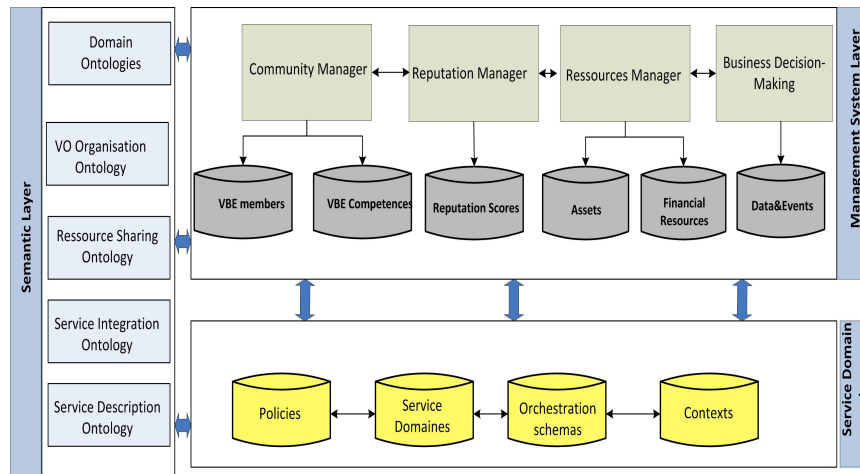


Fig. 1: The proposed framework for VO creation

3.1 The management System Layer

This layer's objective is to assist VBE members with a fluid creation of VOs that correspond to business opportunities. The main elements of the management system level include: Reputation Manager, Community Manager, Ressources Manager and Business decision making manager. These managers are implemented as services, that we call management system services.

The Community Manager

Our approach for VO creation within the VBE context is based on the concept of community. Organizations belonging to communities can participate in VBES initiated by other organizations. However, their membership in the community does not impose their participation in collaborative scenarios. A community groups organizations with the same kind of activity. Its establishment is designer-driven and starts as follows. Initially, the community administrator defines the functionality like "Automobile Assembling" of a community. Afterwards, he deploys the community manager that will lead this community. This manager undertakes many functions that we can classify into three categories: community management functions, organization attraction and retention functions, and organizations nomination and selection functions for participation in on demand collaborative business processes. Once the community is created, the community manager is responsible for inviting organizations to sign up in this community and checking their credentials. In addition, it proposes functionalities to store, access, delete, and modify the member's company and contact information.

Besides, the community manager is responsible for attracting new organizations to the community and retaining existing one. Attracting new organizations makes the community manager regularly consult web pages and portals looking for new members. Moreover, organizing and managing of member profiles and competences is a key activity of the community manager. The need for management of profiles is

an important issue especially in medium-size and large-size VBEs, where typically the member organizations do not have the chance of getting to know all others directly. In our approach, member profile consists of descriptive information about the business. This would include information such as name and descriptions, contact information and classification information. This information is essential to analyze the suitability of each organization for involvement in a VO creation. VBE member organizations competencies are divided into two categories: core organizational values which describe the essential managerial competencies for the organization and the technical and functional competencies for the organization described through the list of service domains proposed by the organization. Service domains are composite structure used as major building block for implementing on demand VO. In the following we describe the service domain concept and the rationale behind using this service for VO creation.

Dismantling a community is designer-driven as well and happens upon request from the community manager. The community manager monitors all events happening in a community such as the arrival of new organizations, departure of existing ones, identification of organisation's services to be part of collaborative business processes, and imposing sanctions on organizations in case of misbehavior. If the community manager notices that (i) the number of organizations in the community is less than a certain threshold and (ii) the number of participation requests in VO creation over a certain period of time is less than another threshold, then the community will be dismantled. Both thresholds are predetermined by the designer.

The Reputation Manager

With an increasing number of organizations providing similar services and products, more emphasis is being placed on how to find the organization that best fits the VO's requirements. There are functional requirements that are, what the organizations services or products can do, and non-functional requirements, such as the price and quality of service or product guaranteed by an organization. The problem, however, is that the advertised quality information relating to an organization is not always trustworthy. When it comes to services for example, a service provider may publish inaccurate quality information to attract more customers, or the published quality information may be out of date.

Reputation, besides other selection criteria, has been widely used for evaluating and ranking organizations. Reputation is defined as "the opinion of the public toward a person, a group of people, or an organization. It is an important factor in many fields, such as business, online communities or social status" (Wikipedia Online Dictionary).

Organization reputation can be considered as an aggregation of service ratings for a service from VBE members over a specific period of time. Allowing VBE member to rate the quality they receive from a member's service, and making these ratings public, can provide new VBE members with valuable information on how to choose services. This provides also a general and overall estimate of the reliability of a VBE member offering the service. With organization reputation taken into consideration, the probability of finding the best service to respond to a business opportunity can be increased.

In the proposed framework service reputation is handled by the reputation manager. Reputation score is calculated based on feedback by service consumers. We assume that service consumers provide a rating indicating the level of satisfaction with a service belonging to the VBE. A rating is an integer ranging from 1 to 10, where 10 denotes extreme satisfaction, 5 denotes average satisfaction and 1 denotes extreme dissatisfaction.

The reputation manager is responsible for collecting the data from service consumers, processing the data, and then updating the reputation score for related service providers. In order to encourage consumers to provide ratings of a service to the reputation manager, a bonus point system may be introduced to award consumers for their feedback.

The computation of reputation score is based on previous work [16],[17] in which a reputation score (RS) of a service belonging to an organization is computed as the weighted average of all ratings the service received from customers, where an inclusion factor is the weight attached to each of the ratings for the service. The ratings of services by consumers are stored in the reputation manager's local database.

The Resource Manager

In the proposed framework, resource manager supports the management of resources including tangible assets, financial resources, materials, and human resources in the VBE. These resources are of common interest and useful for VBE members. Besides, the resource manager purpose is to facilitate the flow of information between all VBE members. By focusing on managing sharable information or data and lessons learned, many opportunities for reuse of functionality will arise, resulting in more efficient use of existing resources. Many researchers in literature are interested in studying the issue of managing resources in virtual organization context [18], [19].

The Business Decision Making Manager

Decision-making is a crucial issue for a successful establishment of a VBE. In the proposed framework, the business decision making manager helps to make information clearer and better analyzed by VBE member. To accomplish its mission, business decision making manager collect, store and manage large volumes of variant, mostly time-series data. Besides, it defines sophisticated events that occur within a VBE; alerts are triggered when those events fall outside of predefined parameters and are delivered to desktop or handheld devices, enabling rapid decision making and crisis management. Examples of these events can be the performance of member organizations in the VBE and sends warning message to the community manager when and if the performance of some VBE member organization falls below certain threshold.

In addition, the business decision making manager has a market and customer oriented role. It observes the needed competencies in the market, which are frequently required by the collaboration opportunities, and compare them with those available within the VBE through its member organizations. Once a gap is detected,

an alert will be sent to the community manager in order to take appropriate action (e.g., encourage organizations with the required competencies to join the VBE).

3.2 Service layer

This layer presents business services exposed by VBE members within a community. Business services correspond to a functional representation of a real world business activity having a meaningful effect to the end-user. The business services can be atomic services called functional or composite services called service domains. Functional services are fine grained services exposing a set of business activities. They are identified when analyzing enterprise business processes. Business activities within a process can be easily identified as belonging to the potential logic that should be encapsulated by a functional service.

Service domain orchestrates a set of functional services and it is used as major building block for implementing on demand VO. The rationale of the service domain concept is to abstract at a higher-level the integration of a large number of functional services. A service domain is built upon (in fact, it uses existing standards such as WSDL, SOAP, and UDDI) and enhances the Web service concept. It does not define new application programming interfaces or standards, but hides the complexity of this exercise by facilitating service deployment and self-management.

Besides, in order to ensure that organization can easily adapt to context changes, business services must be more than functions provided through the Web. Indeed, business services must have the capacity to adapt their own behavior by configuring appropriately to the situation in which they evolve. The adaptability of business services within a VO context was the object of our research project in [20], so further details are provided there.

To correspond to VO creation needs and requirements, services domains are governed by a set of policies. Policies might be imposed by different types of initiators like the service itself, the VBE member exposing the service, and the VBE member who plans to use the service. In this paper, we suggest the two types based on some of our previous works [13], [21]:

- Business policy defines the constraints that restrict the completion of a service domain and determines how this service should be executed according VBE member' requirements and VO' internal regulations.
- Behavior policy supports the decisions that a service domain has to make when it receives a request from a VBE member to be part of VO creation. Examples of behaviors can be permission, dispensation, and restriction.

3.3 Semantic Layer

Our proposed framework for the VBE management addresses the heterogeneity problems between the VBE members by providing an ontology-driven integration solution. This solution is based on a set of mediation ontologies which are orthogonal to the two other layers (the service and the management system layers) and aim to extend service and management layer with a semantic that enhance service mediation in the context of a VBE. The main proposed ontologies are: service integration ontology, resource sharing ontology, VO Organization ontology and Domain ontologies. These ontologies are described in detail in the following.

The Service integration ontology

The aim of the service integration ontology is to perform mediation processes in order to resolve mainly the semantic heterogeneity problem between services participating in a VO. In our proposal, we use the hybrid approach to perform service integration. The rationale behind this choice is that in the context of a VBE the definition of a single set of ontology standards that are suitable for all the VBE member is nearly impossible. The service integration ontology is based on a set of modules that perform the matching or resolution of semantic heterogeneity between services [22]. These modules are based on ontology mapping. The mapping is the process whereby two or more ontologies are semantically related at conceptual level. According to the semantic relations defined in the mappings, source ontology instances can then be transformed into target ones [22].

The Resource sharing ontology

In order to support the discovery of relevant information in the context of a VO creation, information resources need to be described in a way that is understandable and usable by the VBE members. To this end, each member should provide an ontological description of its information resources, according to a Semantic Web-compatible language for its specification (e.g., OWL [23]). In order to describe the resources in an ontology language-independent way, we refer to a reference ontology model, in terms of concepts, properties and semantic relations between concepts. A concept is characterized by a name and a set of properties that represents its features. We distinguish between strong and weak properties, to denote mandatory properties and optional properties, respectively. Each property is associated with a name and a value, which can be a datatype or a reference to another concept. Semantic relations are defined between concepts, to express the most appropriate relations existing between them.

The VO Organization ontology

We consider VO organization ontology to be a set of constraints on the activities performed by VBE members. In particular, VO organization consists of a set of divisions and subdivisions, a set of organization-members (which are the members of a division of the organization), a set of roles that the members play in the organization, and an organization-goal tree that specifies the goals (and their decomposition into subgoals) the VO try to achieve.

The Domain ontologies

Domain ontologies are required to help in the collaborative work and ensure that organizations are negotiating about the same good/product/service. Organization may use different ontologies to represent their view of a domain. Each domain may be specified in many different ways, and this ontology mismatch is a question under intensive research. For example, a domain expert may derive a domain-specific ontology that describes the vocabularies for concept used within a sector. In our work, we adopt the domain ontologies specification as the one reported in [22].

4. Related Work

There are many ongoing research efforts related to the VO creation framework within a VO Breeding Environment context. The most relevant work in this area is proposed by Camarinah-Matos et al. within the ECOLEAD project [1]. This work characterizes a first attempt to the definition of a reference framework for VO creation that addresses the fundamental elements of the VBEs. The proposed framework presents a detailed process covering a number of steps from the identification of the collaboration opportunity till the launching of the VO. Besides, the framework is validated through empirical studies relating to international industry based VBE involved in the ECOLEAD project.

In a recent work, the authors present an excellent approach for the establishment and management of 2nd generation VBEs and fluid formation and creation of VOs [24].

The key aspects of the approach are: a reference framework, value systems and trust management, a VBE management system and contract negotiation wizard.

Zirpins et al. in [26] introduce a SOA model for virtual service enterprises. In particular, the authors propose an UML-based SOA metamodel for realisation of services that represent virtual service processes. However, the proposed approach doesn't include any facility to manage the virtual services within a VO context.

While most of the previous endeavors have been focused on particular aspects namely on the VBE management system, partners' selection and VO creation process, one of the innovative contributions of this work is the consideration of a holistic approach covering VBE management system, interoperability issues and service domain adapted to enterprise collaboration.

5. Conclusion

The VO Breeding Environment enables dynamic and fluid establishment of potential opportunity-based virtual organizations. However, its implementation in a real organization context is more challenging and requires a particular attention, a comprehensive guiding framework and strong engineering principles. In this paper we have proposed a three layered framework combining VBE management systems layer that assist flexible VO creation, a semantic interoperability layer essential for promoting integration on the basis of comment language that describe VO concepts and inherent dependencies, and a service oriented layer that introduces the concept of service domain that encapsulates business processes fitting VO requirements.

As to future work, an empirical study to validate and test the proposed approach will be at the centre of ongoing research. For other related endeavors, modeling the inter-organizational trust and management of performance measurements appear to be a promising path as well.

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